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AUTHOR Schroth, Marvin L.
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ABSTRACT

Fluid intelligence (Gf) is a general relation-perceiving capacity determined by each person's cortical, neurological connection count development. Its processes are involved in reasoning, concept formation and problem-solving, where acculturation has little effect. Crystallized intelligence (Gc) manifests knowledge and general comprehension, reflecting both Gf and education/acculturation over time. Elderly subjects (N=224) were tested to examine the relationship between Gf and Gc abilities, two types of problem-solving tasks, and educational level. Gf correlated more with performance than did Gc on tasks using abstract stimuli and deemphasizing past experiences. No significant difference was found between Gf and Gc with respect to problem-solving tasks involving concrete stimuli and an emphasis on past performance. The correlation between Gf and Gc was significantly higher for subjects with more education. Additionally, educational level correlated highly with success on both types of problem-solving tasks. Overall results indicated that educational level was important in accounting for ability-problem-solving relationships among the aged. (Author/NRB)

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A MULTIVARIATE ANALYSIS OF AGING, CONCEPT FORMATION AND INTELLIGENCE

Marvin L. Schroth, Ph.D.[1]
University of Santa Clara

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FOOTNOTE

The author, Marvin L. Schroth, can be reached at the Psychology Department, University of Santa Clara, Santa Clara, California 95053.

A Multivariate Analysis of Aging,

Concept Formation and Intelligence

The subject of aging-intelligence relationships has historically been a major source of controversy among psychologists and shows no signs of abating (Maturazzo, 1972; Horn and Donaldson, 1976; Baltes and Schaie, 1976; Birren and Schaie, 1977; Horn, 1978; Botwinick, 1978). Not surprisingly, the relationship between intellectual abilities and problem solving, among older adults, is also ambiguous as previous studies have failed to yield consistent trends (Bromley, 1957; Young, 1966; Botwinick, 1973; Wetherick, 1969; Birren and Schaie, 1977; Hayslip and Sterns, 1979). Accordingly, the prupose of the present study was to conduct a multivariate analysis of fluid and crystallized abilities and their relationship to problem solving among elderly adults.

Cattell and Horn make a distinction between two types of intelligence, each having a different ontogenetic pattern of change (Cattell, 1943, 1963, 1968, 1971; Horn, 1970, 1976, 1978; Horn and Cattell, 1966a, b, 1967). Fluid intelligence (Gf) is conceived as a general relation-perceiving capacity which is determined by each individual's unique endowment in cortical, neurological connection count development. Its processes are involved in reasoning, concept formation and problem solving, where educational/ acculturation has little affect (Horn, 1978). Crystallized intelligence (Gc), on the other hand, manifests knowledge and general comprehension. Over a period of several years it reflects both the physiological state of the brain (fluid intelligence) and education/acculturation (Horn, 1978).

Fluid ability develops until around 14 years of age, and then begins

to show a decline after approximately age 20 whereas, in contrast, Gc continues to grow and develop to age 40 and possibly beyond (Cattell, 1971). Consequently, Gf and Gc appear to show differential paths of growth and decline due to decreased neurological efficiency vs acculturation, respectively. As discussed by Hayslip and Sterns (1979) and Horn (1978), there should be a decreasing correlation and perhaps independency in Gf-Gc abilities with advancing age. However, the evidence on this Gf-Gc hypothesis is contradictory. For example, Cunningham and Clayton (1973), Cunningham et al. (1975), Birren et al. (1963) and Foulds and Raven (1948) reported a decreasing Gf-Gc correlation with age, but others (Arnold, 1973; Hayslip and Sterns, 1979) have found an increase.

Turning to the area of problem solving, a two factor model has been proposed by Davis (1966) which parallels what Cattell and Horn have provided for the investigation of intelligence. Type "O" problems are those for which the subject has formed few pre-experimental associations and has to test various responses, in the beginning, by trial and error. Concept formation tasks, involving abstract unfamiliar stimuli, are an example of this type of task. Type "C" problems, on the other hand, involve responses which are already known to the subject, due to pre-experimental trial and error learning. In the case of these tasks, the stimulus materials are typically familiar and concrete. Familiar Type "C" problems are arithmetic, anagrams, and "insight" tasks.

As discussed in detail by Hayslip and Sterns (1979), a relationship is hypothesized to exist between the Cattell-Horn two-factor theory of intelligence and the Davis bipartite model of problem solving. Type "C" tasks and Gc ability both emphasize past experience, whereas Type "O" tasks and Gf ability

de-emphasize past learning and, instead, stress measurement of thinking processes on the immediate task (Horn, 1978; Hayslip and Sterns, 1979). Hence, substantial relationships should exist between Type "C" performance and Gc, and Type "O" performance and Gf.

In the Hayslip and Sterns (1979) study, no differences in correlation between Gf-Gc abilities and Type "C" problem solving were found; however, Gf did correlate significantly higher with Type "O" learning than did Gc.

The present study further investigated relationships between fluid and crystallized ability and Type "O"/Type "C" problem solving. A major goal was to examine the role of amount of education and its relationships to both types of intelligence and problem solving. Extrapolating from the Cattell-Horn theory of intelligence, (Cattell, 1963, 1971; Horn, 1970, 1978), it is hypothesized that level of education will correlate more highly with Gc than Gf ability. Furthermore, it is inferred from the aforementioned Davis (1968) model of problem solving that amount of education will show a more substantial relationship to Type "C" than Type "O" problems. Both Type "C" problems and Gc ability are said to depend on previous experience while Type "O" problems and Gf ability are not. Although education is known to correlate higher with ability and performance than with age (Cunningham and Birren, 1976), it was not investigated as an independent variable in the Hayslip and Sterns (1979) experiment.

METHOD

Subjects.--Two hundred and twenty-four adults, evenly divided between men and women, from the nonresidential Santa Clara Senior Citizens Center served as subjects. They ranged in age from 60-79, with a median of 67.44. All subjects were retired and had no noticeable physical or mental handicaps that would affect their test and problem solving performances. The median

number of years of formal education was 12.35 years with a range of 9-20.

Intelligence and problem solving measures.--All subjects were administered the Raven's Progressive Matrix test and the Vocabulary subtest from the Wechsler Adult Intelligence Scale (WAIS) to measure fluid and crystallized abilities, respectively. These tests have been widely used because of their reliability and high correlation with major tests of IQ (Cunningham, et. al., 1975; Anastasi, 1976).

A problem solving task that was selected to represent the Type "O" problem was a conjunctive concept identification task similar to one employed by Schroth (1976). The conjunctive problem consisted of stimuli varying in two dimensions, form and color. The values of the form dimension were figures X, H, and O. Values of the color dimension were red, green and blue. A reception paradigm, as described in Hulse et al. (1975), was used in which subjects were instructed as to the meaning of the terms "conjunctive concepts," negative and positive instances, dimensions and values as used in the task. They were given one card at a time (a trial) and informed to place it in one of two piles, depending on whether they thought it was a positive or negative instance. Informative feedback (right or wrong) was provided verbally; the post feedback interval was 5 seconds. All concepts were selected at random, prior to testing, and each subject was tested individually. Testing was carried out to a criterion of 9 out of 10 correct responses or until 100 trials were completed.

A task selected to represent the Type "C" problem was the arithmetic subtest from the WAIS. This problem is concrete in nature and, according to Davis (1966), emphasizes the role of pre-experimental associations. All subjects were administered both Type "O" and Type "C" tasks.

The intelligence and problem solving tasks were counterbalanced in order to control for the effects of such extraneous variables as fatigue, subtest position, learning sets and cautiousness, all noted to affect cognitive performance in the elderly (Botwinick, 1978; Areburg, 1973; Furry and Baltes, 1973; Hultsch, 1971, 1974; Craik, 1968; Crovitz, 1966; Levinson and Reese, 1967; Kamin, 1957).

RESULTS

Table 1 shows the raw score means and standard deviations on the Raven's Progressive Matrix test and the Vocabulary and Arithmetic subtests from the WAIS. The mean number of trials to reach the criterion of nine out of ten successive correct responses or 100 trials, and standard deviations on the concept identification task are also included. Scores on the task were subsequently transformed into reciprocals (Winter, 1971) in order to stabilize variance; distributions on all other variables were normal.

Place Table 1 about here

Pearson product moment correlations, using Z scores to standardize variables, were computed to determine interrelationships between Gf, Gc, problem solving tasks and amount of education. In regard to the latter variable, subjects were divided into two groups, above and below the median, to assess the relationship between educational level and intelligence-problem solving factors.

To test for possible sex difference, "t" tests were conducted for each intelligence and problem solving variable. All proved to be insignificant at the .05 level.

The overall product moment correlation between Gf and Gc was +.51, $p < .01$. Additional product moment correlations were conducted on them by amount of education, median = 12.35 years. The correlation between Gf and Gc, for

subjects above the median in education, was +.76 and +.31, for those below the median, both significant at the .01 level. However, use of the Hotelling "t" test for differences between correlations reveals that Gf and Gc correlate significantly higher among the better educated subjects than with those with less education, $p < .01$.

Table 2 shows correlations between intelligence and problem solving variables with corresponding "t" values. All correlations between intelligence and problem solving tasks proved to be significant ($p < .01$). However, Gf correlated significantly higher ($p < .01$) with success at Type "O" problem solving than did Gc; no significant difference was found between Gf and Gc in their relationships to Type "C" learning.

Place Table 2 about here

Finally amount of education correlated significantly with both problem solving tasks at the .01 level, +.48 with Type "O" and +.52 with Type "C". The Hotelling "t" test of significance of difference for pairs of correlated coefficients was insignificant at the .05 level.

DISCUSSION

A strong relationship was found to exist between Gf and Gc in the elderly population which does not support the Cattell-Horn hypothesis about the disparity that occurs with increasing age between the two abilities. The findings are in agreement with those of Hayslip and Sterns (1979) and Arnold (1973), but not with the results reported by others (Cunningham and Clayton, 1973; Cunningham et al., 1975; Birren et al., 1963; Foulds and Raven, 1948). One explanation for the previously reported disparity in findings is that the investigators reporting high correlations used multiple measures of Gf and Gc while others, who found low relationships, employed a single measure of each ability (Hayslip and Sterns, 1979). However, findings of the current

experiment substantiate the Hayslip and Sterns (1979) and Arnold (1973) results even though single measures of Gf and Gc were used while the latter studies involved multiple measures.

An important variable, under current investigation and relevant to the above disparity in results, is amount of education. The correlation between Gf and Gc abilities was significantly higher among the well educated than for the less educated. While level of education was controlled for in previous experiments (Arnold, 1973; Cunningham and Clayton, 1973; Cunningham et al., 1975; Birren et al., 1963; and Foulds and Raven, 1948), it was not investigated as an independent variable. Hence, it appears that in stating Gf-Gc relationships for the aged, their level of education must be taken into consideration, with the correlation being much stronger among the highly educated.

These results, in regard to education, have additional implications for the Cattell-Horn Gf-Gc theory. As previously alluded to, Gf is said to reflect the cortical, neurological state of the brain, and hence is unaffected by culture-educational factors, whereas Gc is related to both Gf and culture-education variables (Cattell, 1943, 1963, 1968, 1971; Horn, 1970, 1976, 1978; Horn and Cattell, 1966a, b, 1967). The present data suggest, however, that Gf is affected by amount of education as the correlation between the two abilities is much higher among the well educated older people than those with fewer years of formal schooling. One hypothesis, of course, is that the Cattell-Horn theory, in regard to Gf, needs to be revised because Gf may be a function of more than just the physiological state of the brain. However, another plausible hypothesis, beyond the scope of this paper, is that the well-educated tend to be more mentally active, having been provided with more resources to draw upon in retirement than poorly educated people, and in return, this affects the physiological state of the brain. Diamond (1978) summarizes research

purporting to show that the external environment does play a large role in maintaining brain cells during aging. For a discussion of biological processes of the brain and learning, in general, see Swenson (1980).

The data concerning correlations between types of abilities and problem solving tasks are in agreement with the Hayslip and Sterns (1979) findings and partially support the predictions about ability-problem solving relationships. Fluid ability was found to significantly correlate higher with the Type "O" task than Gc, as was expected since abstraction was involved in the concept identification problem. However, no significant difference was found between Gf vs Gc and Type "C" problem solving. This latter finding may be explained by an analysis of the arithmetic task used to measure Type "C" learning. Obviously arithmetic problems do require pre-experimental experiences and "all-or-none" scoring, both requisites for Type "C" problems as discussed by Davis (1966). Nevertheless, abstraction also seems to be involved and vital to success on such problems. This, of course, is part of the description of Gf. As stated above, the results are in agreement with the Hanslip and Sterns (1979) study in which anagrams were used to represent Type "C" tasks.

Further analysis on the data, concerning amount of education, indicate it to be an equally important source of variation for both Type "O" and Type "C" tasks, although the latter is stated to be more dependent on pre-experimental experiences. The importance of level of education to problem solving, in general, among the aged has been established by previous investigators (Cunningham and Birren, 1976; Botwinick, 1973), as they report performance to be more highly correlated with education than with age.

Overall, the present data to raise questions concerning the nature of

Gf-Gc differences, their relation to problem solving, and aging. The role of amount of education in affecting ability-problem solving relationships among the elderly must be taken into consideration in future studies. Furthermore, a fertile area of research for the future lies in uncovering how education or mental stimulation, in general, is related to the physiological state of the brain, hereby possibly affecting Gf ability in the aged.

REFERENCES

Anastasi, A. Psychological testing, (4th Ed.). McMillian, New York, 1976.

Arenberg, D. Cognition and aging: Verbal learning, problem solving and memory. In C. Eisodorfer and M. P. Lawton (Eds.), The psychology of adult development and aging. American Psychological Assoc., Washington, D.C., 1973.

Arnold, W. R. Heart rate response measures related to human abilities: A cross-sectional evaluation of fluid and crystallized intelligence. Unpublished doctoral dissertation. West Virginia Univ., 1973.

Bates, P. B., and Schaie, W. K. On the plasticity of intelligence in adulthood and old age: Where Horn and Donaldson fail. American Psychologist, 1976, 31, 720-725.

Birren, J. E., Botwinick, J., Weiss, A., and Morrison, D. G. Interrelations of mental and perceptual tests given to healthy elderly men. In J. E. Birren, R. N. Butler, S. W. Greenhouse, L. Sokoloff and M. Yarrow (Eds.), Human aging: A biological and behavioral study. NIMH, USPHS Publ. No. 986. USG PO, Washington, D.C., 1963.

Birren, J. E., and Schaie, W. K. Handbook of the Psychology of Aging. Van Nostrand and Reinhold Company, New York, 1977.

Botwinick, J. Aging and behavior (Rev. Ed.). Springer, New York, 1978.

Botwinick, J. Aging and behavior: A comprehensive integration of research findings. Springer, New York, 1973.

Bromley, D. B. Some effects of age on the quality of intellectual output. Journal of Gerontology, 1957, 12, 218-232.

Cattell, R. B. Abilities: Their structure, growth and action. Houghton-Mifflin, Boston, 1971.

Cattell, R. B. Are I.Q. tests intelligent? Psychology Today, 1968, 2, 56-62.

Cattell, R. B. The measurement of adult intelligence. Psychological Bulletin, 1943, 41, 153-193.

Cattell, R. B. Theory of fluid and crystallized intelligence: A critical experiment. Journal of Educational Psychology, 1963, 54, 1-22.

Craik, F. M. Short-term memory and the aging process. In G. A. Talland (Ed.), Human aging and behavior. Academic Press, New York, 1968.

Crovitz, E. Reversing a learning deficit in the aged. Journal of Gerontology, 1966, 21, 235-238.

Cunningham, W. R. and Birren, J. E. Age changes in human abilities: A 28-year longitudinal study. Developmental Psychology, 1976, 12, 81-82.

Cunningham, W. R., Clayton, V. "Fluid" and "Crystallized" intelligence in the elderly. Proceedings of the 81st Annual American Psychological Association Convention, 1973, 771-772.

Cunningham, W. R., Clayton, V., and Overton, W. Fluid and crystallized intelligence in young adulthood and old age. Journal of Gerontology, 1975, 30, 53-55.

Davis, G. A. Current status of research and theory in human problem solving. Psychological Bulletin, 1966, 66, 36-54.

Diamond, M. C. The aging brain: Some enlightening and optimistic results. American Scientist, 1978, 66, 66-71.

Foulds, G. A., and Raven, H. C. Normal changes in the mental abilities of adults as age advances. Journal of Mental Science, 1948, 94, 133-142.

Furry, C. A., and Baltes, P. B. The effect of age differences in ability-extraneous performance variables on the assessment of intelligence in children, adults, and the elderly. Journal of Gerontology, 1973, 28, 73-80.

Hayslip, B., Jr., and Sterns, H. L. Age differences in relationships between

crystallized and fluid intelligences and problem solving. Journal of Gerontology, 1979, 34, 404-414.

Horn, J. L. Human abilities: A review of the research and theory in the early 1970s. Annual Review of Psychology, 1976.

Horn, J. L. Human ability systems. In P. B. Baltes (Ed.), Life span development and behavior. Academic Press, New York, 1978.

Horn, J. L. Organization of data on life span development of abilities. In L. R. Goulet and P. B. Baltes (Eds.), Life span development psychology: Theory and research. Academic Press, New York, 1970.

Horn, J. L., and Cattell, R. B. Age differences in fluid and crystallized intelligence. Acta Psychologica, 1967, 26, 107-129.

Horn, J. L. and Cattell, R. B. Age differences in primary mental abilities factors. Journal of Gerontology, 1966, 21, 210-229. (a)

Horn, J. L. and Cattell, R. B. Refinement and test of the theory of fluid and crystallized general intelligences. Journal of Educational Psychology, 1966, 57, 253-270. (b)

Horn, J. L. and Donaldson, G. On the myth of intellectual decline in adulthood. American Psychologist, 1976, 31, 701-719.

Hulse, S. H., Deese, J., and Egeth, H. The psychology of learning, (4th Ed.). McGraw-Hill, New York, 1975.

Hultsch, D. F. Adult age differences in free classification and free recall. Developmental Psychology, 1971, 4, 338-347.

Hultsch, D. F. Learning to learn in adulthood. Journal of Gerontology, 1974, 29, 302-308.

Kamin, L. J. Differential changes in mental ability in old age. Journal of Gerontology, 1957, 12, 66-70.

Levinson, B., and Reese, H. W. Patterns of discrimination learning set in preschool children, fifth-graders, college freshmen, and the aged. Monographs of the Society for Research in Child Development, 1967, 32, Whole No. 7.

Maturazzo, J. D. Wechsler's measurement and appraisal of adult intelligence, 5th Ed.. Williams and Wilkins, Baltimore, 1972.

Schroth, M. L. Acquisition of Conjunctive concepts under different postfeedback conditions. Perceptual and Motor Skills, 1976, 41, 771-776.

Swenson, L. C. Theories of learning: traditional perspectives/contemporary developments. Wadsworth, Belmont, Calif., 1960.

Wetherick, N. E. The psychology of aging. Occupational Therapy, 1969, 32, 15-17.

Winer, B. J. Statistical principles in experimental design, (2nd Ed.). McGraw-Hill, New York, 1971.

Young, M. L. Probelm-solving performance in two age groups. Journal of Gerontology, 1966, 21, 505-509.

Table 1. Means and SDs for Ability Tests and Problem Solving Tasks

Group [a] Variable	Mean	SD
Gf[1]	26.12	7.05
Gc[2]	62.83	10.81
WA Task[3]	12.14	3.71
CI Task[4]	21.89	11.33

[a] $n = 224$

1. Fluid Ability (Ravens Profressive Matrix), "Raw" Scores
2. Crystallized Ability (WAIS Vocabulary Subtest), "Raw" Scores
3. Type "C" Task (WAIS Arithmetic Subtest), "Raw" Scores
4. Type "O" Task (Concept Identification Subtest), Trials to Criterion

Table 2. Hotelling t Values for Differences between Correlations Involving Problem Solving by Type of Intelligence

Correlation of:	Type "O"		Type "C"	
	Correlations:	t	Correlations:	t
Gf[1]	.72**	*3.62	.69**	.41
Gc[2]	.49**		.64**	

*p < .05

**p < .01

1. Gf--fluid intelligence
2. Gc--crystallized intelligence